DESIGN AND FABRICATION OF A HIC COMPLIANT BULKHEAD

Principal Investigator:
Hamid Lankarani
Professor of Mechanical Engineering and NIAR Senior Fellow
National Institute for Aviation Research
Wichita State University
Wichita, KS 67260-0091
Phone: (316) 978-6307, Fax: (316) 978-3236
Email: Lankaran@me.twsu.edu

FAA Technical Monitor/Contacts: Steve Soltis, Gary Frings, Tong Vu
Participants: NIAR/WSU, FAA-TC, FAA-CAMI

The need for head injury protection has been addressed with the inclusion of the Head Injury Criteria, (*HIC*), in the dynamic seat certification requirements specified in paragraph 562 of the Federal Aviation Regulations Part 23, 25, 27, and 29. Compliance with the *HIC* poses a significant problem for many segments of the aircraft industry. The certification requires engineers to demonstrate that a head strike into any one of several cabin furnishing complies with a *HIC* threshold of 1000. The problem encountered in the certification of 16G seats, referred to as the front row *HIC* problem, occurs for seats located behind bulkheads and cabin class dividers. These structures are typically stiff and hence produce unacceptably large *HIC* values. This research is directed towards the design and fabrication of a bulkhead for *HIC* attenuation, meeting the industry's appearance and aesthetic requirements as well.

The goal of this research was to demonstrate the "*Proof of Concept"* that there are potential solutions for the bulkhead-*HIC* problem. The project was also aimed at generating a design methodology for the development of bulkheads for *HIC* attenuation. The study conducted on various honeycomb materials for *HIC* attenuation has been reported. MADYMO biodynamic simulations, supported by simple quasi-static tests, were developed for the design of *HIC* compliant bulkheads which effectively attenuated *HIC* below the injury levels. The validated MADYMO models were utilized for a parametric study of the effects of stiffness and strength of the bulkhead on *HIC* levels and to develop design heuristics for the fabrication of *HIC* compliant bulkheads. New bulkhead designs and materials were derived, statically tested for the load-deflection properties and the results were compared with design curves. The compliance of the new bulkheads for *HIC* was then assessed by conducting full-scale dynamic sled tests on these structures at both small and large seat setback distances. This study also produced a detailed methodology for the design and development of *HIC* compliant bulkheads.

A methodology developed for the design of a *HIC* compliant bulkhead is shown in figure 1. The initial bulkhead design is based on aircraft cabin requirements and previous experience. The stiffness of the bulkhead is determined by: a) hybrid analytical method, b) finite element analysis, or c) static test. The initial stiffness of the bulkhead at the point of head impact is compared with the allowable threshold from the design curves. If the stiffness is below the limiting value of 480 lb/in for 33-in seat setback and 709 lb/in for 35-in seat setback distance, the design should meet the *HIC* requirement. This shall then be verified by dynamic sled test(s) performed on the bulkheads.

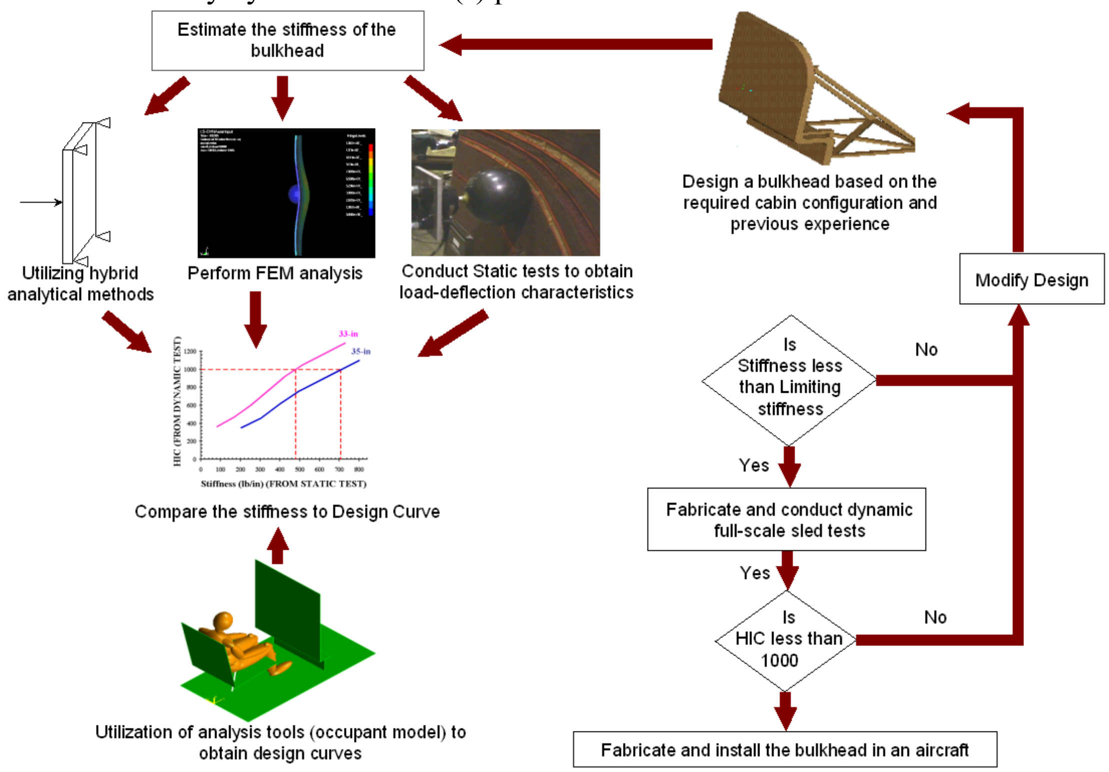

FIGURE 1. DESIGN METHODOLOGY FOR *HIC* COMPLIANT BULKHEAD

Three series of honeycomb type bulkhead materials were evaluated for *HIC* compliance. The bulkheads were subjected to static tests in order to evaluate their initial stiffness at the head impact location. The bulkheads were then tested dynamically to evaluate the *HIC* and related head acceleration data. It was observed that the first bulkhead series failed to meet the *HIC* requirement for a 35-inch seat setback distance. The second series bulkheads failed at 33-inch seat setback distance but may be a potential solution at a 35-inch seat setback distance. Series III bulkheads performed well at both 35-inch and 33-inch seat setback distances.

The study also produced some generic design guidelines for the selection of the bulkhead material. The methodology requires an estimate of the initial stiffness of the bulkhead. This may be accomplished by: hybrid analytical method, finite element method, or static test. The following criteria are recommended for the design of aircraft bulkheads or cabin class divider panels:

a) The initial stiffness of the panel should be less than 480 lb/in for 33-inch seat setback distance;
b) The initial stiffness of the panel should be less than 709 lb/in for 35-inch seat setback distance;
c) The panel should be able to permanently crush 2-4 inches.